The Diagnostics and Verification System for the Tile Calorimeter Trigger and Data Acquisition framework of the ATLAS Detector

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Abstract. During the maintenance period of the Front-End electronics of the Tile Calorimeter of the ATLAS detector, the state of the electronics has to be assessed, first by confirming existing problems, and secondly by assessing the validity of the repairs. The Diagnostics and Verification System (DVS) tests are composed of checks that are used to verify the functionality of the TileCal front-end (FE) electronics and is used mostly during the maintenance period. The DVS implements similar tests to the Mobile Integrity Check (MobiDick) in an embedded system. MobiDick is the first level tests after repairs, and the DVS follows at the second level when the module is inserted back into position and connected to the TDAQ system. The current high-precision DVS tests available for the TileCal are run from the command-line using two separate programs executed on separate computers. This is not efficient and is mostly understood by TileCal Data Acquisition (DAQ) experts.

1. Introduction

The ATLAS (A Toroidal LHC Apparatus) detector is one the two multipurpose experiments at the Large Hadron Collider and it is utilized for the search of new physics. It consists of four main components namely the inner detector, calorimeter, muon spectrometer and magnet system. The hadronic Tile Calorimeter is a sampling calorimeter that resides in the innermost part of the ATLAS detector and it is used to measure energies carried by charged and neutral particles. It uses steel as an absorber medium and scintillating tiles as the active medium. It consists of two extended barrels (EB) and one central long barrel (LB). The system is split into four partitions such as EBA and EBC for the extended barrel and LBA and LBC for the long barrel [1]. Each partition constitutes 64 azimuthally segmented modules which are commonly known as the super-drawers. The super-drawer consists of Front-End electronics such as the digitizer boards, adder boards, interface boards, photo-multiplier tubes, 3-in-1 cards and High voltage divider boards that needs to assessed and maintained during the Long and Short Shut-down.

The ATLAS Online Software is in charge of the overall experimental configuration of the AT-

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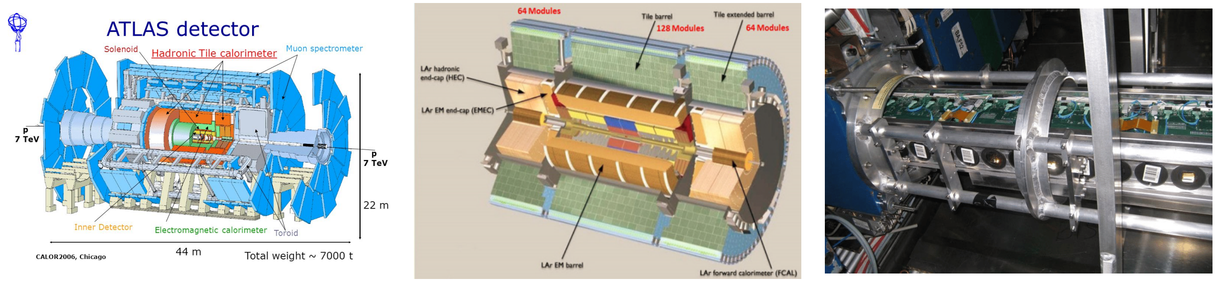

Figure 1. ATLAS Detector (left) , Tile Calorimeter (middle) and Super-Drawer (right)

LAS detector including the run control. It monitors the Trigger and Data Acquisition systems software (TDAQ), which is a system that reduces the vast amount of data from the collisions to a manageable amount. The trigger system checks the data and selects events with distinguishing characteristics that makes them suitable for the physics analysis. The data acquisition system channels the data from the detector to storage. The main purpose of the online software is to readout, transport, and to store data that originates from the proton-proton collisions. It must synchronize and collaborate with the other ATLAS sub-systems, in particular, interfaces are required for the data-flow, triggers, processor farms, event builder, detector read-out crate controllers and Detector Control System (DCS) [2, 3].

The Control subsystem of the ATLAS detector supervises the individual detector components as well as the experimental infrastructure. The DCS includes a number of software packages that enables equipment supervision using operator commands, reads, processes and archives the operational parameters of the detector, allows for error recognition and handling, manages the communication with external control systems, and provides a synchronization mechanism with the physics data acquisition system. The Diagnostics and Verification system is part of the software packages of the DCS. It is utilized for checking and diagnosing faults in the front-end components of the detector [3].

2. The Diagnostics and Verification System

The DVS is part of the ATLAS Online TDAQ software. It is a supporting structure that allows TDAQ developers and experts to combine tests and knowledge into it, thus making it user-friendly for a non-experienced shift operator to be able to diagnose problems within the TDAQ component. There are two types of TDAQ users namely the TDAQ operator and the TDAQ expert. The TDAQ Expert is mainly involved in the implementation, configuration and storing tests in the database while the role of the TDAQ operator is to perform tests on the components [3, 4].

The DVS tests are a set of digital checks that examines the functionality of the components of the super-drawer. They are similar to the Mobile Drawer Integrity Checking System (MobiDick) in the sense that they check assess the functionality of the individual components of the super-drawer. The MobiDick and DVS tests differs in aspects of how the test is being performed. For the MobiDick testing the drawer has to be opened while the drawer has to remain closed for the dvs testing. DVS are second level tests that follows immediately after MobiDick to verify the faults found in the components.

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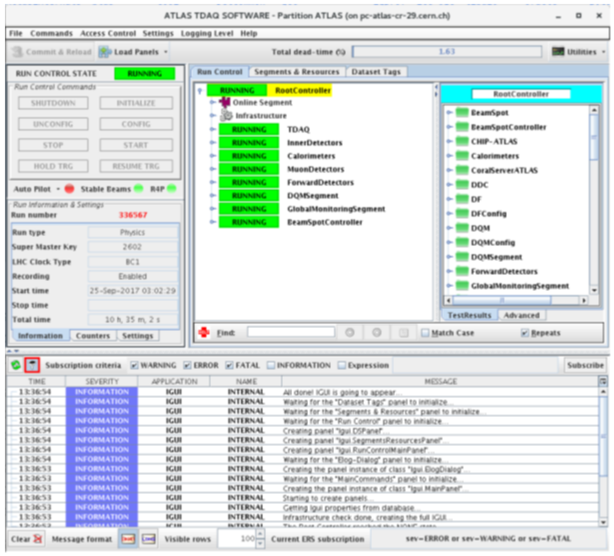

Figure 2. The DVS GUI

2.1. DVS Implementation and Graphical User Interface

The DVS can be accessed by human users (TDAQ operator) via the DVS Graphical User Interface (GUI) or by online software packages (TDAQ supervisor) via the Application Programming Interface (API). To be able to implement the required functionality, the DVS reads the TDAQ configuration via the configuration databases service, it then launches the tests via the test manager and then use the CLIPS ("C" language Integrated Production System) packages to implement the expert system [3]. The DVS has an internal architecture that is composed of the following:

- A Test Repository Database: A database that describes the attributes of a test in the configuration database. The test attributes are described in the form of classes in this case the classes are *Test, Test4Object or Test4Class*
- A knowledgeable Base: Store specific Knowledge about component functionality.
- An Expert System Engine: Available via the C/C++ API.
- C++ and Java Libraries
- A Graphical User Interface application: The user interface used for DVS is the partition. The hardware components are described in the configuration database of the ATLAS TDAQ. Tests are configured using the Test Manager which reads the OKS (Object Kernel System) configuration database to select tests to be executed. Tests have to be collected in Test Repositories and linked to the Partition or one of its Segments [3]. The user can select any component on the partition and perform tests specific for that component.

2.2. DVS Tests

There are several types of DVS tests:

- Charge Injection Scan (CIS): This test checks the existence of a pulse inside some bands for high and low gains.
- Pedestal Test: This test checks the low and high frequency values and compares it to nominal values.

- Data Management Unit (DMU) Memory: This is a test whereby a bitwise pattern is written to the DMU memory and then pattern data is read out and checked for errors.
- Stress: This is a test whereby a 100 kHz random trigger and a full busy logic is used to reject the acquisition. Data is processed inside the Digital Signal Processor. The number of the Cyclic Redundancy Check (CRC) errors found in the data is reported.
- Digitizer Address: The test checks the correct address of the digitizer board [4].

Although there are a number of the DVS tests. The TDAQ experts focuses only on the CIS and Pedestal tests.

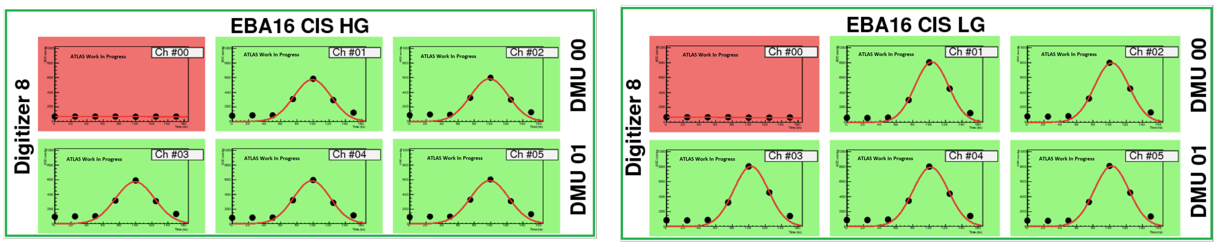

Figure 3. Results for the charge injection scan for high and low gains for EBA16

Figure 3 displays the results for the Charge Injection Scan DVS test for the sixteenth Extended Barrel (EBA16) module in the low and high gain. A Gaussian function is fit through the samples for pulse recognition. The plots are also color coded, green means everything is fine, and red means that something is wrong with that particular channel i.e channel 0. A channel is associated with the photo-multiplier tube number and the Data Management Unit (DMU). Finding a problem in a certain channel makes it easy to determine which electronic is faulty. After testing the module using dvs, the module is repaired and tested again to confirm the repair.

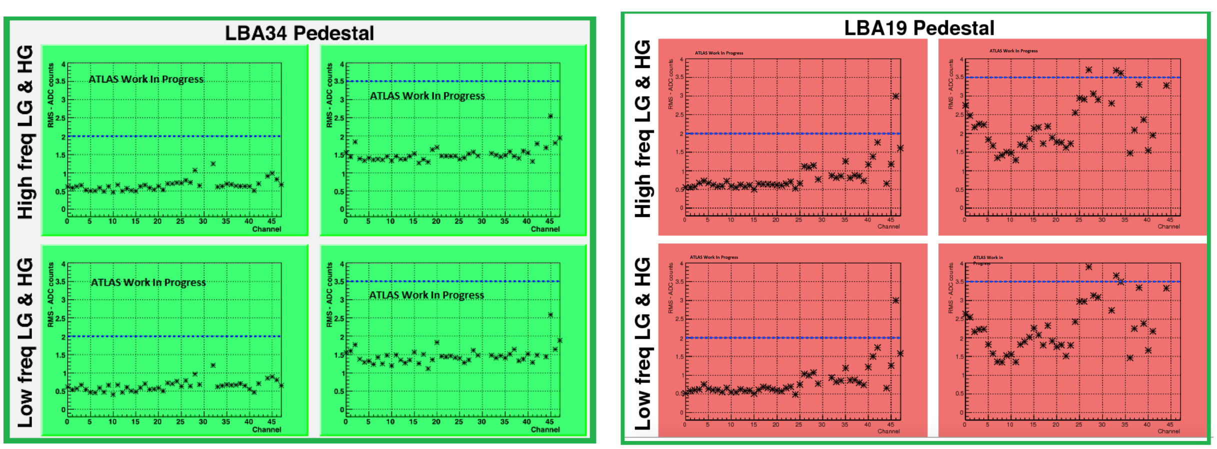

Figure 4. Results for the high and low frequency noise pedestal tests

Figure 4 displays the high and low frequency noise for the Long Barrel number 17 and 34 (LBA19 and LBA34) . LBA19 had a bad response in both the low and high gains. LBA34 had a good response in both gains. The low and high gains refers to the Analogue to Digital Converter (ADC) gains. The gains are chosen automatically by the DMUs. If the number of ADC counts in High Gain (HG) is 1023 for at least 1 of the data samples, then the gain is switched to Low Gain (LG). If the number of ADC counts in HG is 0, then the gain is switched to LG.

3. Conclusion

The Diagnostics and Verification tests are implemented to check the functionality of the super-drawer as well as its components. DVS tests are digital tests that checks for faults in the drawer while the drawer is closed. They are designed similar to MobiDick tests but are carried out later to assess the Tile FE electronics later on after the maintenance period. Sometimes after a drawer repair, negative feedback comes one day later from the offline team about specific errors that both DVS and MobiDick are not designed to detect. More DVS tests are currently being implemented to be able to improve the quality assurance procedure after the repairs. In particular, a stuckbit test is currently being implemented by the author, which is currently not available in DVS but it is in MobiDick.

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